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Gallium-67 for the Diagnosis and Localization of Subphrenic Abscesses

G. BRUCE HOPKINS, MD, *and* CHRISTIAN W. MENDE, MD, *La Jolla, California*

Four septic patients with suspected subphrenic abscess were evaluated with gallium-67 citrate and technetium-99m labeled radiopharmaceuticals. Gallium-67 scintigraphs proved instrumental in correctly diagnosing and localizing one left and three right subphrenic abscesses. Gallium-67 scintigraphy can be a useful noninvasive technique for evaluating patients with suspected subphrenic abscess.

SUBPHRENIC ABSCESSES continue to present a challenging clinical problem. They generally occur spontaneously, most frequently as complications of injuries, diseases or operations of the gastrointestinal tract and less frequently as the result of similar lesions of the genitourinary tract.[1] Because of their insidious onset and obscure nature, diagnosis and localization are difficult and often delayed.[2] This is well attested to by mortality figures that range from 32 percent to 56 percent or higher if multiple abscesses coexist.[3,4] Routine noninvasive techniques used to evaluate these patients, including chest and abdominal roentgenograms, abdominal ultrasonography and combined liver-lung scintigraphy, frequently yield equivocal or misleading results due to complicating clinical features such as basilar atelectasis, pleural or peritoneal effusions, pulmonary emboli, chronic obstructive pulmonary disease or cysts.

The principle interest in gallium-67 (^{67}Ga) has centered on its tumor-localizing properties.[5-7] Although investigators have noted ^{67}Ga localization in inflammatory lesions[8] and in experimentally produced abscesses,[9] its use in septic patients has received little emphasis. Littenberg and coworkers[10] recently reported focal ^{67}Ga accumulation in 11 septic patients. In all 11 the region delineated by scintigraphy proved to be the source of sepsis. Gallium-67 localization in hepatic abscesses and acutely inflamed gallbladders has also been recorded.[11,12] This report is addressed to the use of ^{67}Ga in patients with suspected subphrenic abscess.

Methods and Materials

Gallium-67 (^{67}Ga) is a cyclotron-produced radionuclide supplied as a sterile and pyogen-free citrate by several commercial manufacturers. It decays by electron capture, has a physical half-life of 78 hours, and produces gamma rays with energies of 93, 184, 296 and 388 kilo electron volts (kev), which are suitable for imaging with either scintillation cameras or rectilinear scanners.

Technetium-99m (^{99m}Tc) decays with a six-hour physical half-life emitting monoenergetic 140

From the Division of Nuclear Medicine, Department of Pathology (Dr. Hopkins) and the Department of Medicine (Dr. Mende), Scripps Memorial Hospital, La Jolla.

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Reprint requests to: G. B. Hopkins, MD, Nuclear Medicine, Department of Pathology, Scripps Memorial Hospital, La Jolla, CA 92037.

kev gamma radiation. The liver and spleen were visualized using ^{99m}Tc-sulfur colloid while ^{99m}Tc-human albumin microspheres were used to image the lungs. These agents were prepared in the Nuclear Medicine Laboratory from commercially available kits.*

Three studies commenced six hours and the fourth ten hours following the intravenous administration of 3 to 5 millicuries (mc) of ^{67}Ga citrate. The studies were made on a Searle Pho-Gamma III-HP scintillation camera using the 184 or 296 kev photopeaks, a 20 percent window and a medium energy diverging collimator. Combined liver-lung, liver-spleen, or lung scintigraphs using 2 mc of ^{99m}Tc-sulfur colloid and 2 mc of ^{99m}Tc-human albumin microspheres were obtained at the same time. When doing the combined liver-lung study, the liver was imaged before injection of the ^{99m}Tc-human albumin microspheres for lung imaging. The 140 kev photopeak of ^{99m}Tc differs sufficiently from the 296 kev photopeak of ^{67}Ga so that combined studies using both radiopharmaceuticals are possible. The patient is maintained in the same position and single or double exposures, using window settings for ^{67}Ga and ^{99m}Tc respectively, are made on polaroid film. This can provide additional helpful information as illustrated in the case reports.

Results

Four septic patients with suspected subphrenic abscess were evaluated with ^{67}Ga citrate and ^{99m}Tc labeled radiopharmaceuticals. Gallium-67 scintigraphs proved instrumental in correctly diagnosing and localizing one left and three right subphrenic abscesses. Each case was confirmed by surgical procedure or drain placement. One patient (Case 2) had amoebiasis with secondary infection by enteric bacteria. The abscesses in the remaining patients contained a mixture of enteric organisms. Two patients with right subphrenic abscess had equivocal results using ^{99m}Tc labeled radiopharmaceuticals and the conventional liver-lung imaging technique. Gallium-67 scintigraphs in both patients clearly gave abnormal findings (Cases 3 and 4).

*New England Nuclear Technetium-99m Sulfur Colloid Kit; 3M Brand Human Albumin Microsphere Kit.

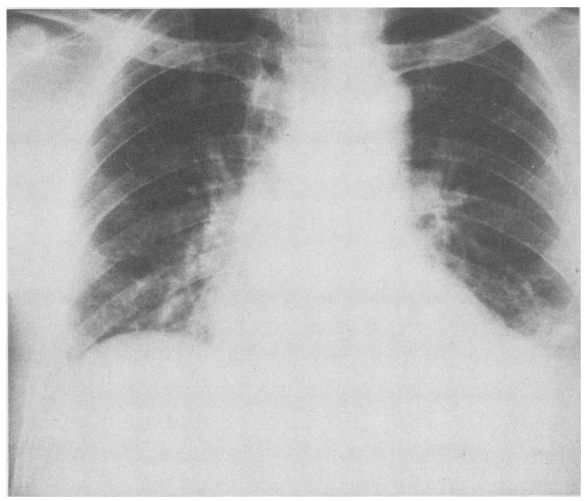

Figure 1.—(Case 1) Roentgenogram of the chest showing atelectasis and consolidation of the left lower lobe.

Reports of Cases

CASE 1. A 45-year-old man was admitted to Scripps Memorial Hospital with fever, temperatures spiking to 102.8°F (39.3°C), chills and left costovertebral tenderness. The patient had been discharged five weeks earlier following a left pyelonephrolithotomy and insertion of a left nephrostomy tube. On admission a chest roentgenogram showed atelectasis and consolidation of the left lower lobe (Figure 1). Findings on an ultrasound study were consistent with a left subphrenic mass. Gallium-67 scintigraphy showed a large focus of ^{67}Ga localization in the left subphrenic area. A combined study using ^{99m}Tc labeled human albumin microspheres to image the lungs proved helpful in placing the ^{67}Ga

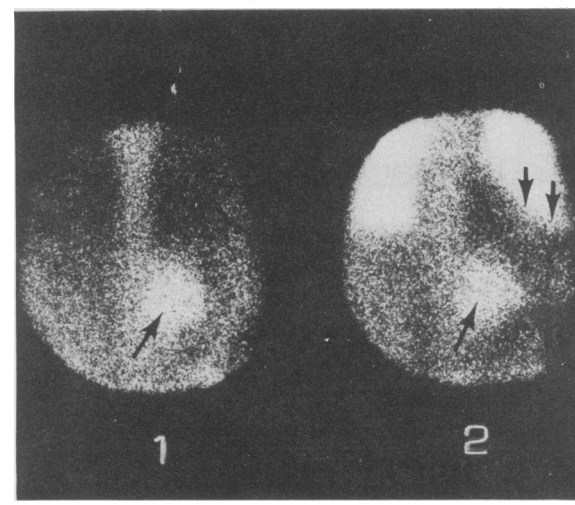

Figure 2.—(Case 1) Anterior chest. **Left,** ^{67}Ga citrate scintigraph (1) shows ^{67}Ga localization at the base of the left lung. **Right,** a combined ^{67}Ga citrate-^{99m}Tc-human albumin microsphere study (2) shows the ^{67}Ga localization to be below rather than within the left lower lobe (see Figure 1).

localization below rather than within the consolidated left lower lobe (Figure 2). A left subphrenic abscess containing Escherichia coli and enterococci organisms was found at surgical operation.

CASE 2. A 44-year-old man was admitted to the hospital with fever, jaundice, weight loss, abnormal findings on liver function tests and a right chest empyema. Roentgenograms showed opacification of the right lung. Liver scintiphotos using ^{99m}Tc labeled sulfur colloid showed a focal defect in the dome of the right hepatic lobe. Gallium-67 scintigraphy showed pronounced ^{67}Ga localization at the same site with extension into the subphrenic space and the right side of the chest (Figure 3). On exploratory operation, a perforated diaphragm secondary to an abscess involving the dome of the liver and right subphrenic space was noted, with extension into the right pleural space and right lung. Purulent material from the abscess cavity contained amoebic cysts and bacteroides organisms.

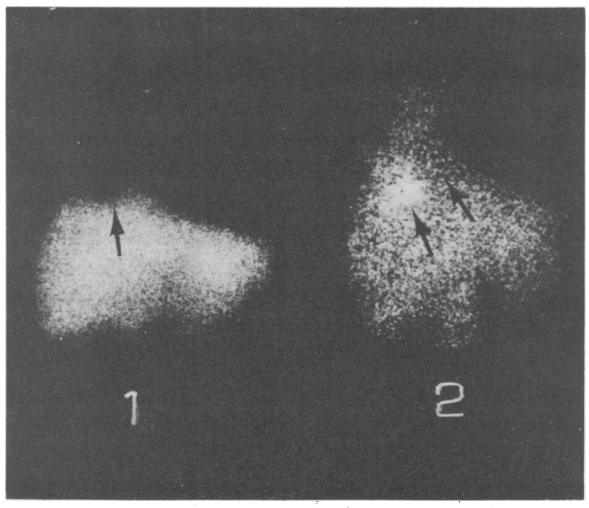

Figure 3.—(Case 2) Anterior liver: **Left,** the ^{99m}Tc sulfur colloid scintigraph (1) shows a defect in the dome of the right hepatic lobe. **Right,** a ^{67}Ga citrate scintigraph (2) obtained in the same position shows ^{67}Ga localization at the same site with extension into the right subphrenic space and right chest.

CASE 3. A 24-year-old woman was admitted with granulomatous colitis and multiple colon perforations. One month after colectomy, fever developed with temperatures spiking to 103°F (39.4°C). A roentgenogram of the chest showed elevation of the right hemidiaphragm. Combined liver-lung scintigraphs using ^{99m}Tc labeled radiopharmaceuticals were equivocal for evidence of a right subphrenic abscess. Gallium-67 scintigraphs clearly showed abnormal ^{67}Ga localization in the right subphrenic space (Figure 4). Drainage of the abscess yielded a mixture of E coli and enterococci organisms.

CASE 4. A 53-year-old man became febrile and lethargic one week following operation for a ruptured appendix and periappendiceal abscess. A roentgenogram of the chest showed elevation of

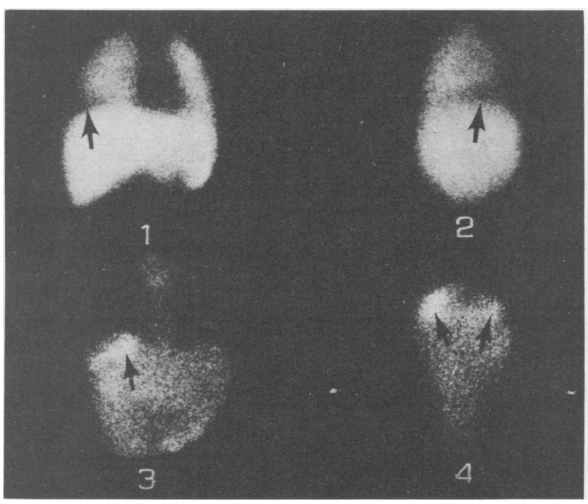

Figure 4.—(Case 3) Anterior (1) and right lateral (2) liver-lung scintigraphs using ^{99m}Tc-sulfur colloid and ^{99m}Tc-human albumin microspheres are equivocal for evidence of a subphrenic abscess while similar views in the same positions (3,4) using ^{67}Ga citrate clearly show ^{67}Ga localization in the right subphrenic space. Note that the loculated posterior abscess seen with ^{67}Ga citrate (4) is not evident on the ^{99m}Tc study (2).

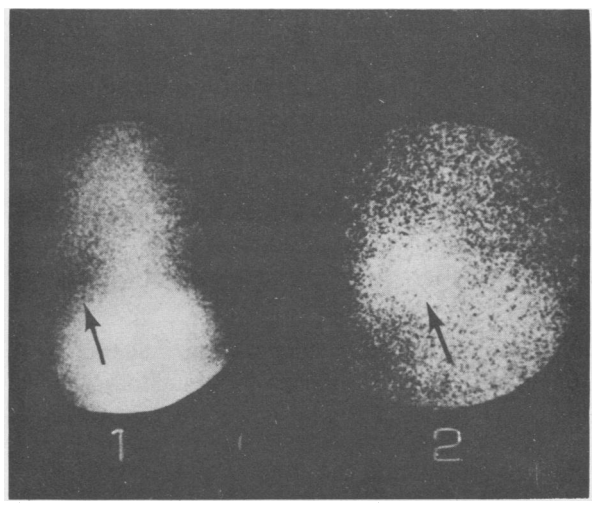

Figure 5.—(Case 4) **Left,** right lateral liver-lung scintigraph (1) using ^{99m}Tc-sulfur colloid and ^{99m}Tc-human albumin microspheres shows posterior separation of the hepatic and pulmonary images. **Right,** a ^{67}Ga scintigraph (2) obtained in the same position shows ^{67}Ga localization in the area of separation.

the right hemidiaphragm. Results of combined liver-lung scintigraphs using ^{99m}Tc labeled radiopharmaceuticals were equivocal with separation of the hepatic and pulmonary images present on only the right lateral view. A ^{67}Ga scintigraph showed ^{67}Ga localization in the area of separation (Figure 5). E coli, enterococci and bacteroides organisms were cultured from the abscess cavity.

Discussion

The scintigraphic finding associated with right subphrenic abscess using ^{99m}Tc labeled radiopharmaceuticals and combined liver-lung imaging technique is separation of the hepatic and pulmonary images on anterior and right lateral or posterior and right lateral views. Displacement of the liver may occur with large abscesses. The result is a cold spot or negative defect lacking specificity. Emphysema, pulmonary emboli, cirrhosis, cysts or pleural and peritoneal effusions may all yield similar scintigraphic findings.[4] The use of ^{67}Ga citrate can increase the specificity of diagnosis by eliminating these noninflammatory causes of false positive liver-lung studies. The number of false negative or equivocal studies may also be reduced as illustrated by two of our cases. Gallium-67 scintigraphy should prove even more valuable in left subphrenic abscess as conventional liver-lung imaging in this area is difficult and unreliable due to the position of the heart and variability in size and position of the left hepatic lobe and spleen.[4]

The current technique observed in most laboratories for ^{67}Ga tumor surveys is to delay scintigraphy 48 to 72 hours following intravenous injection, to insure maximal target-to-background ratios. This delay is unnecessary in septic patients due to the avidity of ^{67}Ga for inflammatory sites. Abscess-to-background ratios sufficient for interpretable scintigraphs may be obtained as early as two hours postinjection.[10]

Clinical and experimental studies suggest that the localization of ^{67}Ga in inflammatory sites is mediated by binding of the radionuclide to intact granulocytes.[13,14] Gallium-67 has been shown to concentrate in granulocytic organelles resembling lysosomes.[15] The increased lysosomal activity of granulocytes may explain the rapid accumulation and subsequent early detection of ^{67}Ga in inflammatory sites. A decrease in circulating granulocytes has correlated with both a diminution in intensity and a delay in onset of ^{67}Ga detection in experimental inflammation.[13]

One potential source of error would be diagnosing subphrenic abscess in a patient with primary or metastatic liver cancer. Generally, the clinical setting of the patient with sepsis is sufficiently different from patients with cancer so that this should not prove a significant problem. If tumor is suspect, positive results should be considered nonspecific and other diagnostic modalities employed.

Whether ^{67}Ga scintigraphy will prove superior to other noninvasive techniques remains to be answered. Based on our limited experience, it does appear to be a valuable adjuvant in the diagnosis and localization of subphrenic abscesses.

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